

# (12) UK Patent Application (19) GB (11) 2 107 207 A

(21) Application No 8227018  
 (22) Date of filing 22 Sep 1982  
 (30) Priority data  
 (31) 304778  
 (32) 23 Sep 1981  
 (33) United States of America (US)

(43) Application published 27 Apr 1983

(51) INT CL<sup>3</sup>  
 B01J 8/24

(52) Domestic classification  
 B1F C1H  
 U1S 1438 B1F

(56) Documents cited  
 None

(58) Field of search  
 B1F

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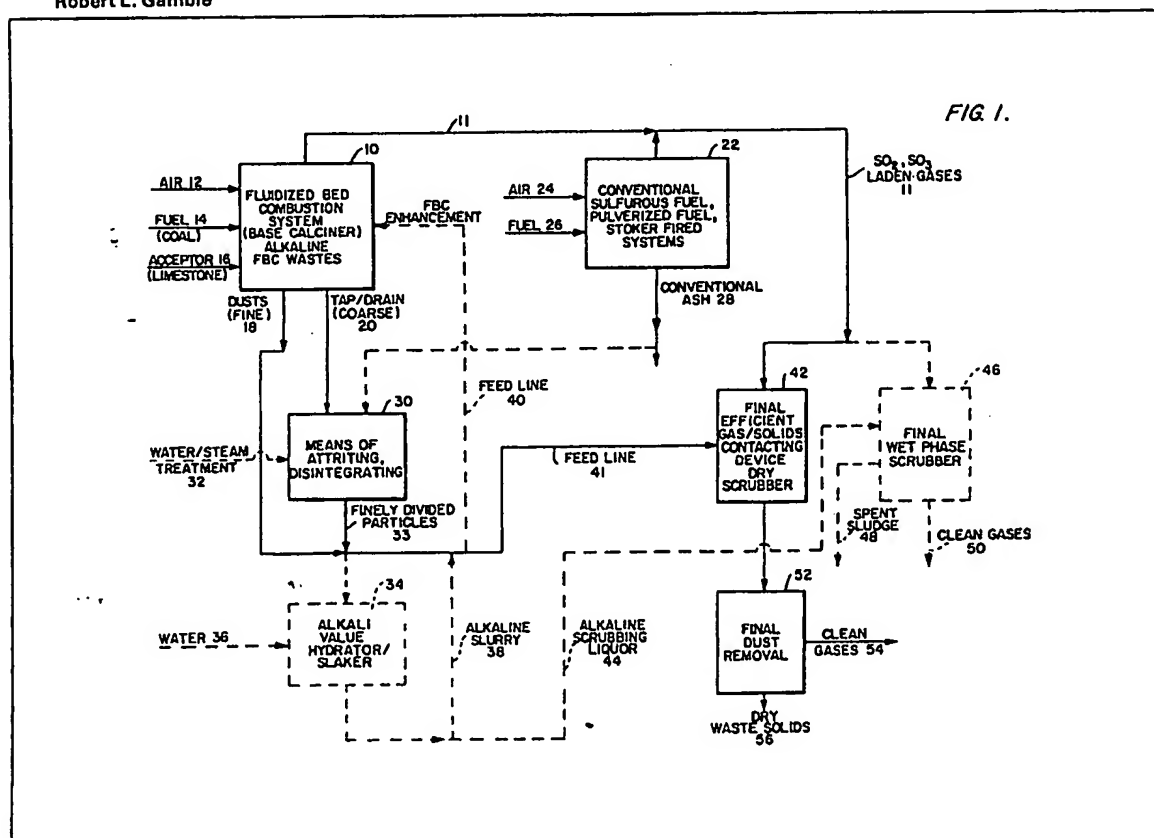
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(54) Flue gas desulphurisation

(57) A process is disclosed for obtaining additional flue gas desulfurization using waste solids from a fluidized bed combustion system in which sulfurous fuels are burned in a bed of acceptor particles. The process comprises the steps of: withdrawing coarse waste particles

from the fluidized bed combustion system (10); subjecting coarse waste particles to mechanical grinding means (30) for attrition and disintegration whereby the waste particles are reduced to a finely divided chemically reactive state (33); and, injecting the finely divided waste particles into the fluidized bed combustion system (10) whereby additional flue gas desulfurization is achieved. In an alternative, the finely divided particles may be used in gas scrubbing (42, 46), in dry form or in the form of a solution or suspension (slurry).



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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FIG. 1.

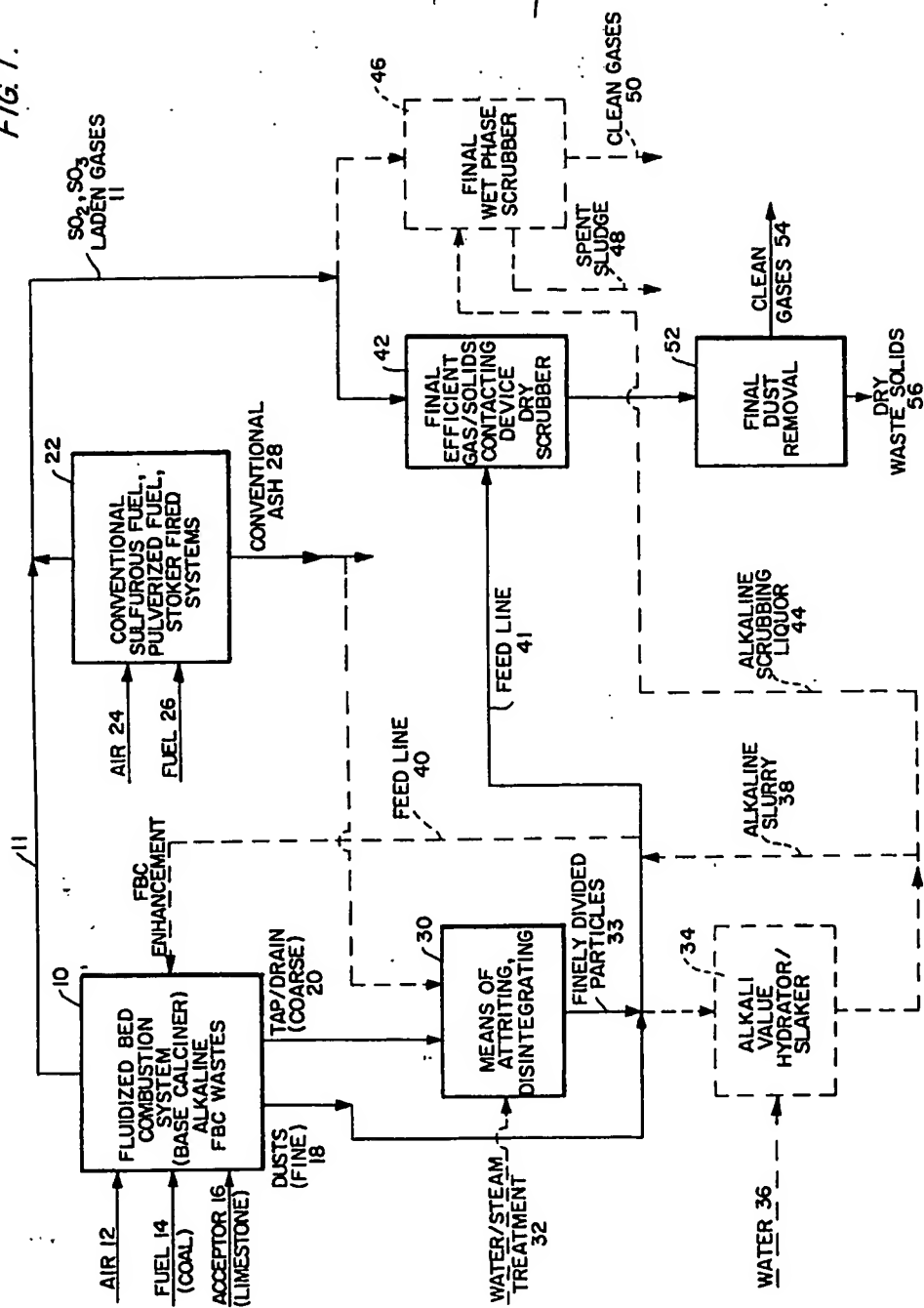
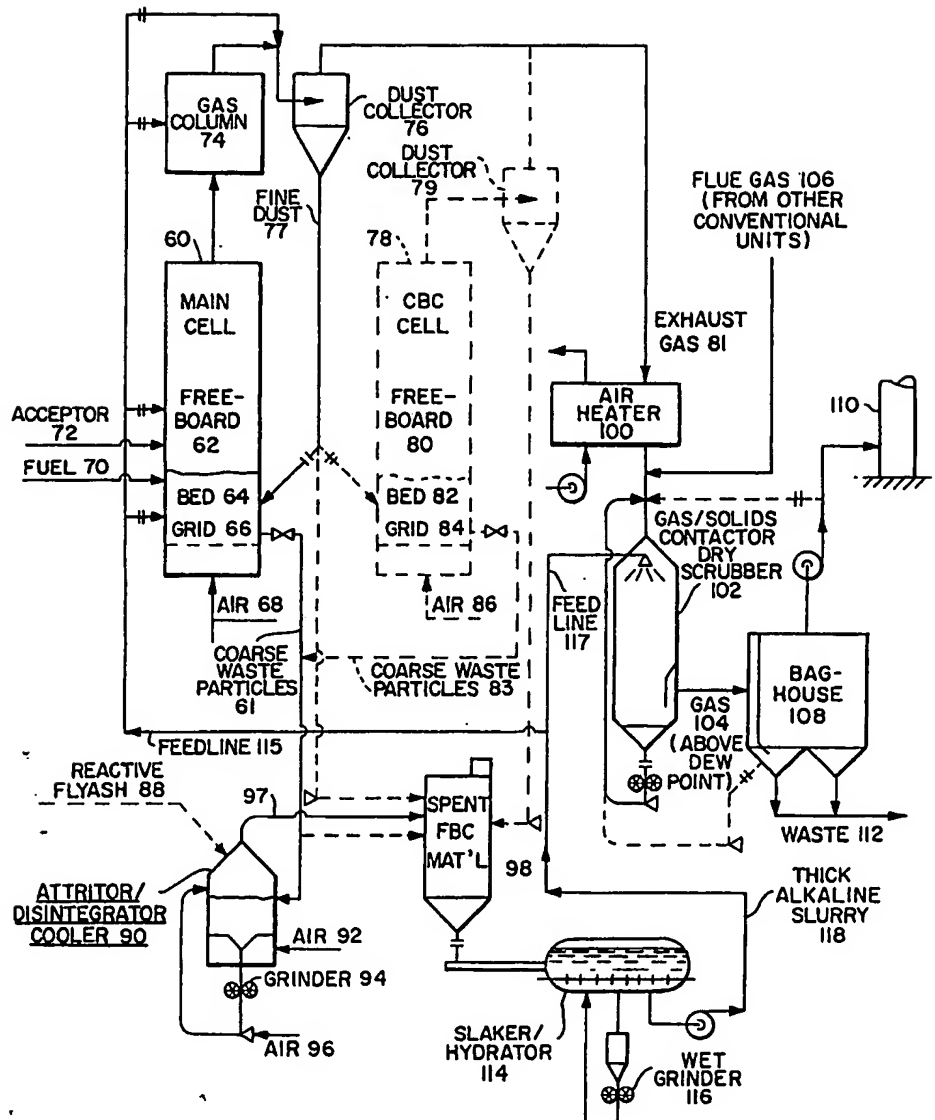


FIG. 2.



**FIG. 3.**

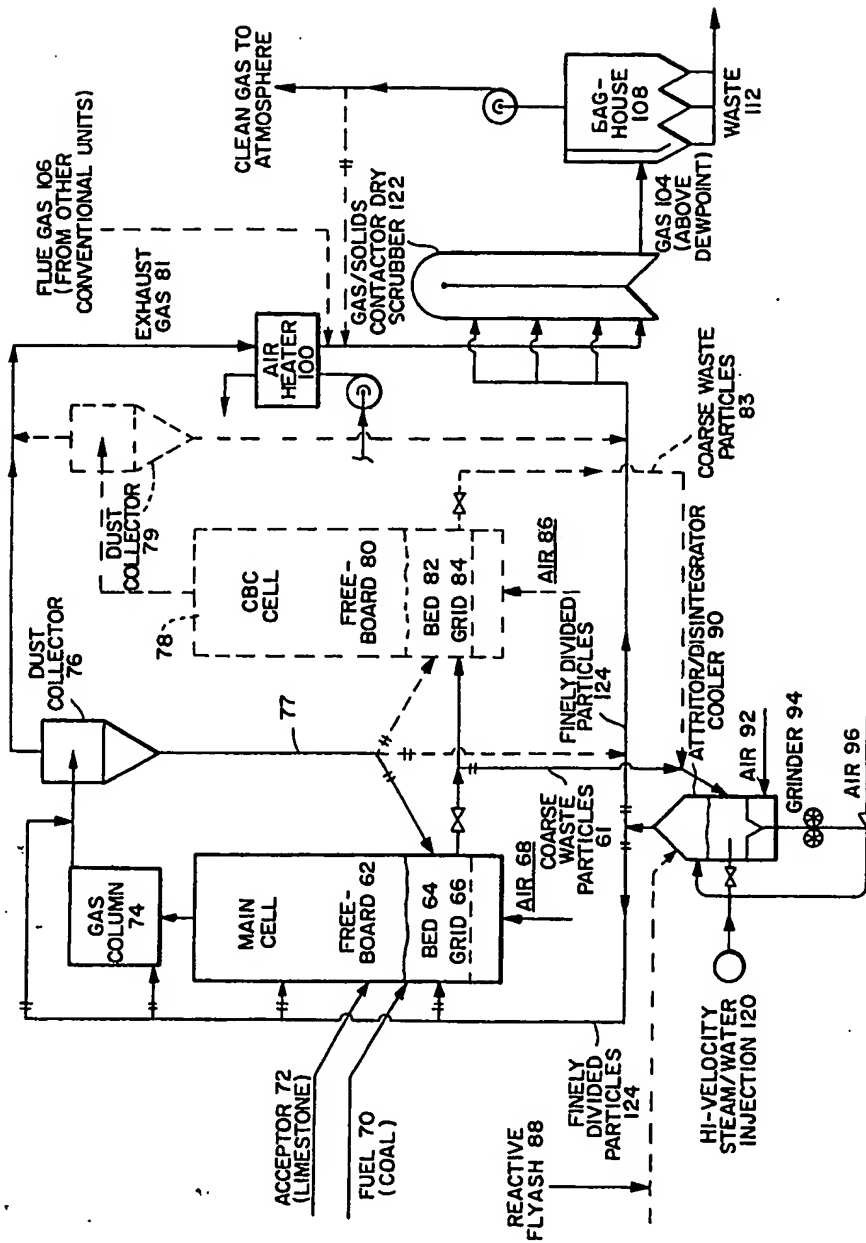
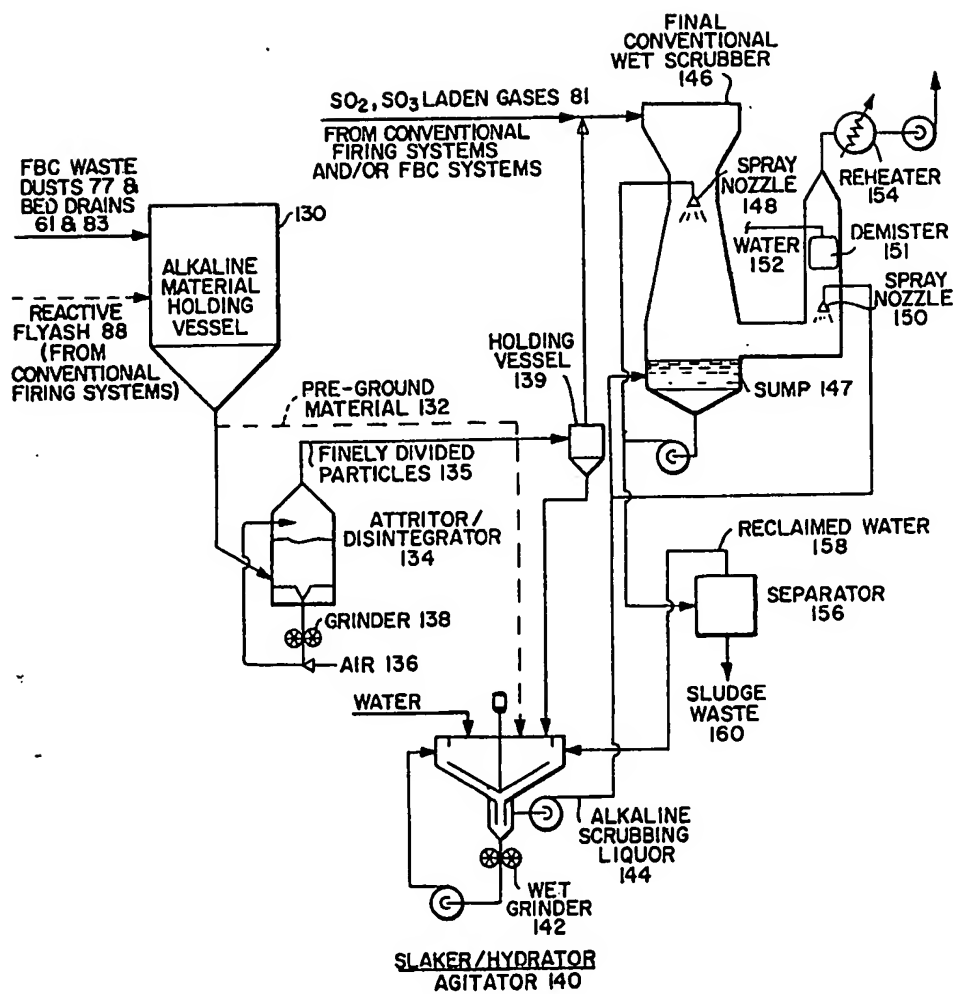


FIG. 4.



## SPECIFICATION

### Flue gas desulfurization

The invention relates to fuel burning fluidized bed combustion systems. More particularly, the invention is directed at methods of using waste solids from a fluidized bed combustion process for obtaining additional flue gas desulfurization.

Fluidized bed combustion systems in which sulfurous fuels are burned in a bed of acceptor (such as limestone, dolomite, etc.) for the purpose of reacting with or capturing sulfur oxides with the acceptor's alkaline compounds ( $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ) characteristically utilize the acceptor inefficiently. Furthermore, where solid fuels, with ashes containing considerable alkaline value, are burned in fluidized bed combustion systems, the process produces a flyash which is more chemically reactive than that produced by conventional firing techniques. Although such ashes may have considerable potential for sulfur capture, they are similarly utilized inefficiently. For example, where bituminous coal is fired with limestone acceptor, the theoretical alkaline value of the acceptor is only 25 to 50% utilized and that of the ash only 10 to 20%.

The present invention seeks to improve the economic performance of the fluidized bed combustion process by more completely utilizing the alkaline chemical value in the usual wastes produced. The fluidized bed combustion process must first act as a calciner for acceptors producing oxides from carbonates, hydrates, bicarbonates, etc. In most conventional dry or wet flue gas desulfurization processes, a premium must be paid for finely ground and/or pre-calcined acceptor. By means of the low cost improvements provided by the present invention, the fluidized bed combustion process is capable of producing finely ground and pre-calcined acceptor.

The present invention provides a process for obtaining additional flue gas desulfurization using waste solids from a fluidized bed combustion system in which sulfurous fuels are burned in a bed of acceptor particles, which process comprises withdrawing coarse waste particles from said fluidized bed combustion system; subjecting such coarse waste particles to attrition and disintegration, reducing them to finely divided particles having increased alkaline chemical value; and injecting such finely divided waste particles into the fluidized bed combustion system to obtain additional flue gas desulfurization. Dust particles may also be collected in the combustion system, and combined with the fine particles for recycling, either as solids, or in a solution or suspension. As an alternative to recycling to the combustion system, the finely divided particles can be used in combination with water as a scrubbing liquor in conventional wet scrubbing apparatus to achieve flue gas desulfurization.

The invention utilizes the waste solids from a fluidized bed combustor having additional alkaline chemical value, to effect the capture of sulfur oxides in the combustion products. Typically

calcined limestone acts as an alkaline acceptor in the fluidized bed combustor and is removed from the fluidized bed as fines in the effluent or as waste solids from the tap of the fluidized bed combustor. The coarser waste solids are combined with the fines and the mixture reduced to a finely divided state before being re-introduced into the fluidized bed in a powder, slurry or solution form. Alternatively, the mixture can be used as a gas scrubbing media in wet and/or dry scrubbers.

In processes of the present invention, waste solids are reduced to a finely divided chemically reactive state for use in a dry powder form, in a thick alkaline slurry form, or in a thin alkaline solution form, as follows:—

a) As an improvement of the basic fluidized bed combustion process by injecting activated wastes into: the bed; the freeboard; the gas collection column (multibed units); before primary dust collection; and, before final dust collection (as with dry scrubbing);

b) For use as a scrubbing media for other conventional combustion systems producing sulfur oxide laden gases. This use may be in conjunction with or independent from the fluidized bed combustion unit producing the media. Where ashes from conventional systems are reactive, they can be integrated into the process.

Thus, the fluidized bed combustion wastes, which are normally produced, can be activated and used to improve the sulfur removal efficiency and the acceptor utilization efficiency of the basic fluidized bed combustion process.

Furthermore, the fluidized bed combustion wastes can be used to prepare effective dry or wet scrubbing media for use in desulfurizing gases from conventional combustion systems in conventional scrubbing apparatus such as dry scrubbing apparatus (using proven spray dryer designs) and wet scrubbing apparatus (using venturi designs or tray designs).

The invention will now be described by way of example and with reference to the accompanying drawings wherein:—

Figure 1 is a schematic process diagram illustrating the general principles of the invention;

Figure 2 is a schematic process diagram illustrating the use of fluidized bed combustion wastes in accordance with the invention to improve the performance of the fluidized bed combustion (FBC) process acting as a "dry scrubber" and/or to scrub gases from other conventional combustion units;

Figure 3 is a schematic process diagram illustrating the use of fluidized bed combustion (FBC) wastes in accordance with the invention to improve the performance of the fluidized bed combustion process acting as a "dry scrubber" and/or to scrub gases from other conventional combustion units; and

Figure 4 is a schematic process diagram illustrating the use of fluidized bed combustion (FBC) wastes in accordance with the invention to produce an alkaline scrubbing liquor for flue gas

desulfurization utilizing final conventional wet scrubbing processes.

Figure 1 is a schematic diagram illustrating the general principles of the inventive process using fluidized bed combustion wastes for flue gas desulfurization in conventional combustion systems and to improve the desulfurization performance of fluidized bed combustion systems.

In fluidized bed combustion (FBC) system 10, fuel particles 14 (such as coal) are burned using air 12 in a fluidized bed of acceptor particles 16 (such as limestone) which normally have a particle size range of  $1/8" \times 0$ . FBC system 10 acts as a base calciner for acceptor particles 16, thereby producing alkaline compounds (such as  $\text{CaO}$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ) which react with and capture sulfur oxides produced by the combustion process.

FBC system 10 produces alkaline wastes in two forms: first, as fine size dust particles (flyash) 18 which are collected from the flue gas; and, second, as coarse size waste particles 20 which normally have a size range of  $1/8" \times 0$  which come out from the tap or drain of system 10. FBC system 10 produces exhaust gases 11 laden with  $\text{SO}_2$  and  $\text{SO}_3$  which, without the present invention, may exceed environmental limits. Adjacent to FBC system 10, there may be a conventional combustion system 22, in which fuel particles 26 are burned using air 24, thereby producing conventional ash particles 28 which also may have high alkaline scrubbing value.

Coarse waste particles 20 and conventional ash particles 28, if having high alkaline value, are fed into mechanical grinding means 30 for attriting and disintegrating the waste particles and the ash particles to produce finely divided particles 33. Grinding means 30 may be, for example, a ball mill or a roll mill. Finely divided particles 33 would preferably have a particle size range where 70 to 90% by weight pass through a two hundred mesh sieve. Alternatively, Figure 1 shows that coarse waste particles 20 and ash particles 28 may be fed into a treatment vessel where they are subjected first to water/steam treatment 32 ahead of mechanical grinding means 30. Water/steam treatment 32 explodes hot waste particles 20 and ash particles 28 in order to assist in producing finely divided particles 33.

In one embodiment of the invention, Figure 1 shows that dry finely divided particles 33, now having increased alkaline value, and then combined with fine dust particles 18 and injected through feed line 40 into fluidized bed combustion system 10 to enhance desulfurization in system 10. Dry finely divided particles 33 and fine dust particles 18 may also be injected through feed line 41 into dry scrubber 42 which removes sulfur oxides from exhaust gases 11. The exhaust gases 11 then pass to final dust removal means 52 where dry waste solids 58 are produced and removed and where clean gases 54 exit to the atmosphere.

Figure 1 also shows that dry finely divided particles 33 and fine dust particles 18 can be combined and fed into slaker/hydrator 34 where

they are mixed with water 36 to produce thick alkaline slurry 38, containing calcium hydroxide. Thick alkaline slurry 38 is injected through feed line 40 into fluidized bed combustion system 10 and through feed line 44 into dry scrubber 42 to react with and capture sulfur oxides in exhaust gases 11.

The injection of dry finely divided alkaline waste particles 33 or the injection of thick alkaline slurry 38 into fluidized bed combustion system 10 may improve the direct desulfurization performance enough to obviate the necessity for final gas scrubbing in most cases.

The dry finely divided particles 33 and fine dust particles 18 can be combined and fed into slaker/hydrator 34 where they are mixed with water 36 to produce thin alkaline scrubbing liquor 44, containing calcium hydroxide. Thin alkaline scrubbing liquor 44 is injected into wet scrubber 46 to remove sulfur oxides from exhaust gases 11 to produce clean gases 50 and spend sludge 48 is removed.

Figure 2 shows in more detail one embodiment of the inventive process (shown generally in Figure 1) using a slaker/hydrator to produce a thick alkaline slurry for pressure injection at several points in fluidized bed combustion system 60 having one or more main cells which have freeboard zone 62 above fluidized bed 64 composed of fuel particles 70 and acceptor particles 72 which are fluidized by air 88 flowing up through grid 66.

Exhaust gas 81 passes out through gas column 74 and then to dust collector 76 where fine dust particles (flyash) 77 having alkaline value are removed and reinjected into fluidized bed 64. Alternatively, some of fine dust particles 77 may be conveyed to spent material holding vessel 98. After leaving dust collector 76, exhaust gas 81 then passes through air heater 100 and into gas/solids contactor dry scrubber 102. Exhaust gas 104, at a temperature above the dew point, then passes through bag house 108 where dry waste solids 112 are removed and clean gases exit to the atmosphere through stack 110.

The plant may include a carbon burnup cell (CBC) 78 having freeboard zone 80 above fluidized bed 82 which is fluidized by air 86 flowing up through grid 84. Some of fine dust particles 77 may also be injected into fluidized bed 82 to enhance desulfurization in that bed.

Coarse waste particles 61 from main cell 60 are removed through the tap/drain of the cell and are conveyed to attritor/disintegrator cooler 90 where hot waste particles 61 (typically at a temperature of 1000 to 1500°F) are cooled by air flow 92. Coarse waste particles 83 from carbon burnup cell 78 are similarly removed through the tap/drain of that cell and conveyed to attritor/disintegrator cooler 90. Reactive flyash 88 from any adjacent conventional combustion systems may also be fed into the top of attritor/disintegrator cooler 90.

The combined coarse waste particles flow down through attritor/disintegrator 90 and are

subjected to mechanical grinding means 94 whereby the particles are reduced to a particle size where preferably 70 to 90% by weight will pass through a two hundred mesh sieve. The finely divided particles are then pneumatically conveyed by air flow 96 back into the top of attritor/disintegrator 90 where they are combined with finely divided reactive flyash 88. The combined finely divided particles 97 are then pneumatically conveyed to spent material holding vessel 98. The finely divided particles then pass out the bottom of holding vessel 98 and are fed into slaker/hydrator 114 where they are mixed with water to produce thick alkaline slurry 118 containing calcium hydroxide. If required, the particles may be subjected to a wet grinding process by grinding means 116 and pumped back into hydrator/slaker 114.

Thick alkaline slurry 118 is then pumped through feed line 117 to gas/solids contactor dry scrubber 102 where the slurry is fed in by any suitable conventional injection means such as a system of nozzles. Simultaneously, thick alkaline slurry 118 is pumped through feed line 115 to fluidized bed combustion system 60 where the slurry is injected at several points: at the level of bed 64, at the level of freeboard zone 62, into gas column 74, and into dust collector 76. Any suitable conventional injection means, such as nozzles, may again be used for this purpose. The thick alkaline slurry, which quickly dries to a fine powder, reacts with and captures sulfur oxides, thereby directly enhancing the performance of the fluidized bed combustion system (acting as a "dry scrubber").

Figure 3 shows in more detail another embodiment of the inventive process (shown generally in Figure 1) wherein fluidized bed combustion wastes are reduced to a finely divided state and then pneumatically injected in dry powder form. Elements in Figure 3 which are the same as in Figure 2 bear the same reference numerals.

Fluidized bed combustion system 60 has one or more main cells which have freeboard zone 62 above fluidized bed 64 composed of fuel particles 70 and acceptor particles 72 which are fluidized by air 68 flowing up through grid 66. Exhaust gas 81 passes out through gas column 74 then to dust collector 76 where fine dust particles (flyash) 77 having alkaline value are removed and reinjected into fluidized bed 64. Exhaust gas 81 then passes through air heater 100 and into gas/solids contactor dry scrubber 122. Exhaust gas 104, at a temperature above the dew point, then passes through bag house 108 where dry waste solids 112 are removed and clean gas exits to the atmosphere.

As shown in Figure 3, the plant may include a carbon burnup cell (CBC) 78 having freeboard zone 80 above fluidized bed 82 which is fluidized by air 86 flowing up through grid 84. Some of fine dust particles 77 may also be injected into fluidized bed 82 to enhance desulfurization in that bed.

Coarse waste particles 61 from main cell 60 are removed through the tap/drain of the cell and are conveyed to attritor/disintegrator cooler 90 where hot waste particles 61 are cooled by air flow 92. Coarse waste particles 83 are similarly removed from the tap/drain of carbon burnup cell 78 and conveyed to attritor/disintegrator 90. Reactive flyash 88 from any adjacent conventional combustion systems may also be fed into the top of attritor/disintegrator 90.

The combined coarse waste particles flow down through attritor/disintegrator 90 and are subjected to mechanical grinding means 94 whereby the particles are reduced to a particle size range where preferably 70 to 90 percent by weight will pass through a two hundred mesh sieve. Alternatively, the coarse waste particles may be subjected to high velocity steam/water injection treatment 120 in attritor/disintegrator cooler 90. The steam/water injection treatment performs an in situ/remote slaker/hydrator function to make a finely divided lime product for injection purposes. It should also be understood that attritor/disintegrator cooler 90 shown as an external apparatus in Figure 3 may be constructed to be integral with the fluidized bed combustion system.

The finely divided particles are then pneumatically conveyed by air flow 96 back into the top of attritor/disintegrator 90 where they combine with reactive flyash 88. The combined finely divided particles are then pneumatically conveyed to and injected into gas/solids contactor dry scrubber 122 through any suitable injection means. Simultaneously, finely divided dry particles 124 are pneumatically injected into fluidized bed combustion system 60 at the level of bed 64, at the level of freeboard zone 62, into gas column 74, and into dust collector 76. Any suitable conventional injection means may again be used for this purpose. The finely divided dry particles react with and capture sulfur oxides, thereby directly enhancing the performance of the fluidized bed combustion system acting as a "dry scrubber".

In Figure 4, another embodiment of the inventive process (also shown generally in Figure 1) is illustrated wherein fluidized bed combustion wastes are used to produce a thin alkaline scrubbing liquor or solution for flue gas desulfurization utilizing conventional wet scrubbing processes.

It should be understood that certain elements are not shown in Figure 4 for the sake of clarity. Thus, Figure 4 omits the following common elements shown in Figures 2 and 3: fluidized bed combustion system 60, having one or more main cells 60 which have freeboard zone 62 above fluidized bed 64 composed of fuel particles 70 and acceptor particles 72 which are fluidized by air 68 flowing up through grid 66; exhaust gas 81 which passes through gas column 74 and then to dust collector 76 where fine dust particles (flyash) 77 having alkaline value are removed and reinjected into fluidized bed 64; the plant may also include

carbon burnup cell 78 having freeboard zone 80 above fluidized bed 82 which is fluidized by air 86 flowing up through grid 84; some of fine dust particles 77 may be injected into fluidized bed 82; coarse waste particles 61 are removed through the tap/drain of main cell 60 and conveyed to alkaline material holding vessel 130 shown in Figure 4; coarse waste particles 83 are similarly removed through the tap/drain of carbon burnup cell 78 and conveyed to alkaline material holding vessel 130; and, fine dust particles 77 and reactive flyash 88 from any adjacent conventional combustion system are also fed into alkaline material holding vessel 130.

It should also be understood in connection with the embodiment shown in Figure 4 that the sources of the coarse fluidized bed combustion waste particles, the fine dust particles, and the reactive flyash may be at a remote location. Therefore, the aforementioned material may be transported from the remote location and then be fed into alkaline material holding vessel 130.

As shown in Figure 4, pre-ground material 132 of a sufficiently small particle size is conveyed directly from alkaline material holding vessel 130 to slaker/hydrator agitator 140. Coarse particles of a larger size are fed from holding vessel 130 into attritor/disintegrator 134. The coarse waste particles flow down through mechanical grinding means 138 whereby they are reduced to a particle size range where preferably 70 to 90% by weight will pass through a two hundred mesh sieve. The finely divided particles are then pneumatically conveyed by air flow 136 into the top of attritor/disintegrator 134. Finely divided particles 135 are then pneumatically conveyed to holding vessel 139. A portion of finely divided particles 135 are conveyed out the top of the holding vessel 139 and combined with exhaust gas 81. The remaining portion of finely divided particles 135 pass out the bottom of holding vessel 139 into slaker/hydrator agitator 140. In slaker/hydrator 140, the finely divided particles are mixed with water and subjected to wet grinder 142 are required in order to form alkaline scrubbing liquor 144 containing calcium hydroxide.

Alkaline scrubbing liquor 144 is then pumped to final conventional wet scrubber 146 where the scrubbing liquor is fed into sump 147 and into the scrubbing chamber by any suitable conventional injection means, such as spray nozzle 150, whereby the scrubbing liquor is contacted with sulfur oxide laden exhaust gas 81 and the sulfur oxides are removed. The scrubbing liquor from the bottom of sump 147 is recycled into the scrubbing chamber through spray nozzle 148. The spent scrubbing liquor is pumped to separator 156 where sludge waste 150 is removed and reclaimed water 158 is recycled to slaker/hydrator 140. The clean gas passes out through demister 151, which is periodically washed down with water 152, and then the clean gas passes through reheater means 154 and exits to the atmosphere.

## CLAIMS

1. A process for obtaining additional flue gas desulfurization using waste solids from a fluidized bed combustion system in which sulfurous fuels are burned in a bed of acceptor particles, which process comprises withdrawing coarse waste particles from said fluidized bed combustion system; subjecting such coarse waste particles to attrition and disintegration, reducing them to finely divided particles having increased alkaline chemical value; and injecting such finely divided waste particles into the fluidized bed combustion system to obtain additional flue gas desulfurization.

2. A process according to Claim 1 wherein fine dust particles are collected from the fluidized bed combustion system, which dust particles are combined with the finely divided particles for injection into the fluidized bed combustion system.

3. A process according to Claim 1 or Claim 2 including the step of injecting the finely divided particles into a final gas/solids contacting device.

4. A process according to any preceding Claim wherein said coarse waste particles are reduced to finely divided particles having a particle size range such that 70 to 90% by weight will pass through a two hundred mesh sieve.

5. A process according to any preceding Claim including the steps of collecting ash particles from a conventional combustion system and subjecting such ash particles to attrition and disintegration to reduce them to finely divided particles having increased alkaline chemical value.

6. A process according to any preceding Claim including the step of subjecting the coarse waste particles to a high-velocity steam/water injection treatment to assist in producing finely divided particles.

7. A process according to any preceding Claim wherein the finely divided particles having increased alkaline chemical value are fed into a slaker/hydrator in which they are mixed with water to form an alkaline slurry, the slurry being injected into the fluidized bed combustion system.

8. A process according to Claim 2 and Claim 7 wherein said dust particles are combined with said finely divided particles and fed together into the slaker/hydrator.

9. A process according to Claim 7 or Claim 8 including the step of injecting the alkaline slurry into a final gas/solids contacting device.

10. A process according to any of Claims 7 to 9 including the step of subjecting the alkaline slurry formed in step (3) to wet grinding to reduce the size of the particles in the slurry.

11. A process for flue gas desulfurization using waste solids from a fluidized bed combustion system in which sulfurous fuels are burned in a bed of acceptor particles, comprising the steps of:  
(a) withdrawing coarse waste particles from the fluidized bed combustion system;  
(b) subjecting the coarse waste particles to

- attrition and disintegration whereby the coarse waste particles are reduced to finely divided particles having increased alkaline chemical value;
- 5 (c) feeding the finely divided particles into a slaker/hydrator where they are mixed with water to form an alkaline scrubbing liquor; and
- (d) injecting the alkaline scrubbing liquor into a final conventional wet scrubbing apparatus whereby flue gas desulfurization is achieved.
- 10 12. A process according to Claim 11 wherein fine dust particles are collected from the fluidized bed combustion system and such fine dust particles are combined with the finely divided particles produced in step (b) and fed into the
- 15 slaker/hydrator.
13. A process according to Claim 11 or Claim 12 wherein the coarse waste particles are reduced in step (b) to finely divided particles having a particle size range such that 70 to 90%
- 20 by weight will pass through a two hundred mesh sieve.
14. A process according to any of Claims 11 to 13 including the additional steps of collecting ash particles from a conventional combustion system,
- 25 combining such ash particles with said coarse waste particles, and subjecting the combined ash and coarse waste particles to attrition and disintegration in step (b) to reduce them to finely divided particles having increased alkaline
- 30 chemical value.
15. A process according to any of Claims 11 to 14 including the step of subjecting the alkaline scrubbing liquor formed in step (c) to wet grinding to reduce the size of the particles in the liquor.
- 35 16. A process for flue gas desulfurization substantially as described herein with reference to any of the accompanying drawings.